#2 11-8-01

The Patent Office

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

JC986 U.S. PTO
09/965881
09/28/01

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated - 4 SEP 2001

CERTIFIED COPY OF
PRIORITY DOCUMENT

Patents Form 1/77

Pate[illegible] Act 1977
(Rl[illegible])

THE PATENT OFFICE
C
30 SEP 2000
NEWPORT

The Patent Office

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

RSN/ME/P11018GB 02OCT00 E572425-4 000239
P01/7700 0.00-0023975.6

2. Patent application number
(The Patent Office will fill in this part)

0023975.6

30 SEP 2000

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

MITEL CORPORATION,
350 LEGGET DRIVE,
PO BOX 13089,
KANATA, ONTARIO,
K2K 2W7,
CANADA

Patents ADP number *(if you know it)* 77500450004

If the applicant is a corporate body, give the country/state of its incorporation

ONTARIO, CANADA

4. Title of the invention

NOISE LEVEL CALCULATOR FOR ECHO CANCELLER

5. Name of your agent *(if you have one)*

CRUIKSHANK & FAIRWEATHER,

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

19 ROYAL EXCHANGE SQUARE,
GLASGOW G1 3AE,
UNITED KINGDOM

Patents ADP number *(if you know it)*

547002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	6
Claim(s)	2
Abstract	1
Drawing(s)	2

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	1
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Date

CRUIKSHANK & FAIRWEATHER 29/09/00

12. Name and daytime telephone number of person to contact in the United Kingdom

Dr. R.S. Naismith
0141-221 5767

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

Noise Level Calculator for Echo Canceller

Field Of The Invention

The present invention relates generally to telecommunications systems, and in particular to a noise level calculator for detecting noise in a telephone line echo canceller.

Background Of the Invention

It is known in the design of line echo cancellers which utilize adaptive filters to incorporate a non-linear processor (NLP) for removal of residual echo signals (e.g. due to non-linearity, distortion, or added signal noise). In order to avoid noise switching being heard on the far end side, it is important that the noise level of the signal applied to the NLP be calculated to distinguish between noise and residual echo.

Noise level calculation is also useful in determining if the reference signal applied to the adaptive filter is noise or a non-noise segment. If noise is detected, then updating of the filter coefficients may be suppressed.

Summary Of The Invention

According to the present invention, a noise level calculator is provided for monitoring the noise level of the error signal applied to the NLP and the noise level of the reference signal applied to the adaptive filter, in order to accomplish the objects set forth above. In contrast with prior art noise detectors which track not only the noise segments but also the signal level and conclude that the noise level is directly proportional to the lowest accumulated signal energy, the noise level calculator of the present invention uses the variance in the signal energy to determine background

noise level. Consequently, the noise level calculator of the present invention actually locates the noise periods and adapts to changes in the variance of noise energy during these periods.

Brief Description Of The Drawings

A preferred embodiment of the present invention will now be described in greater detail with reference to the following drawings, in which:

Figure 1 is a block diagram of a line echo canceller employing the noise level calculator of the present invention; and

Figure 2 is a flowchart showing steps for implementing the noise level calculator according to the preferred embodiment.

Detailed Description Of The Preferred Embodiment

With reference to Figure 1, a Line Echo Canceller (LEC) is shown for canceling echo signals from a line echo path (between **Sin-line** and **Rin_line**). An adaptive filter algorithm (typically the well known adaptive LMS algorithm) is implemented within control logic block 9 to perform the echo cancellation function. The adaptive filter output is subtracted within summation block 3 from the input line signal (**Sin-line**) to create an error signal (**ein**). . As discussed above, NLP 5 is provided for removal of residual echo signals due to non-linearity, distortion, added signal noise, etc. A double talk detector 11 is included for disabling the NLP 5 during a double talk condition (i.e. when the near-end party begins talking, in which case the signal becomes near-end speech plus far-end echo).

According to the present invention, a noise level calculator 13 is provided for continually monitoring the noise level for the error signal **ein** as well as for the

reference signal **Rin-line**. The noise level of the error signal is used by the NLP component 5 to decide if the sample is noise or residual echo. If noise is detected, it is transmitted as is but if residual echo is detected, the NLP 5 generates a noise sample. The noise level of the reference signal is used by the adaptive filter algorithm in control block 9 to decide if the signal is speech or noise. If it is noise, the echo canceller coefficients are not updated.

Turning now to Figure 2, a preferred algorithm is shown for implementing the noise level calculator of the present invention. The equations in Figure 2 are written for optimal performance in a C compiler. Two inputs are required for the implementation, namely an input signal, **xin** and a tone decision parameter, **tone_decision**. The internal state of the noise level calculator and its local variables is held in a local workspace, (i.e. the noise level structure set forth below).

The same function is used to calculate the noise level for the reference signal, **Rin_line**, and the error signal, **ein**, of the LEC in Figure 1 The input sample, **xin**, for each noise calculator implementation is chosen to be either **ein** or **Rin_line**.

The Noise Level Structure and the required local variables for each such implementation are as follows, with reference to Figure 2:

Structure (*NoiseLevel):

(*NoiseLevel).count: this is a counter for the sample window

(*NoiseLevel).level: this represents the NoiseLevel

(*NoiseLevel).accum[0]: current accumulation of the input signal

(*NoiseLevel).accum[1]: previous accumulation of the input signal

(*NoiseLevel).variance: variance of the accumulation

(*NoiseLevel).flag_no_update: invalid window flag, Noise Level is not updated

xin: input sample

diff: difference between the previous and current accumulations

tone_decision: flag is 1 if signal is a Tone

nlevel_count: number of accumulations before the Noise Level is updated

The algorithm of the present invention is based on the assumption that the energy variance of a noise segment is much lower than the energy variance of a voice segment. After determining that no tone is present (step A), samples within a window of 256 samples (32 msec) are accumulated (i.e. the signal energy within the window is calculated). (**(*NoiseLevel).accum[0] = (*NoiseLevel).accum[0]+abs(xin)** in step B). When the window is completed (**(NoiseLevel.count>Window_size ?** in step D), the noise level is updated and the result is saved in memory. It is important that the sample accumulation does not exceed a maximum level (**limit (*NoiseLevel).accum[0] to Max_limit**, in step C) in order to ensure that the variance and noise level calculations do not become corrupted. In the event that the accumulation is invalid (**Yes (accum is invalid)**, in step D), the Noise Level is not evaluated for the next two windows (as a result of the flag being set at **(*NoiseLevel).flag_no_update = 2** in step C and then twice decremented **(*NoiseLevel.flag_no_update-=1** in step D). Two windows are considered invalid at start up as well as when the Max-limit has been reached. They are not used, so as to fill in or clear the history of accumulations respectively.

When two valid accumulations of samples are available, the difference is calculated, which is then used to update the variance of these accumulations as a weighted average of the difference and the previous values of the variance parameter (i.e. **(*NoiseLevel).variance+= (diff – (*NoiseLevel.variance)>>3)** adjusts the variance parameter to the existing (i.e. previous) variance parameter plus a multiple (÷8) of the difference (diff) minus of the previous variance parameter, and **(*NoiseLevel.variance= diff)** adjusts the variance parameter to the previous variance parameter. Thus, in the embodiment of Figure 2, the variance is calculated/updated with an attack ratio of 1 and a decay ratio of 8 (i.e. >>3 in step E). These attack and decay rates were chosen empirically so that the noise level is not updated during short periods of low energy (e.g. caused by fricatives in a voice segment). Alternatively, other attack and decay ratios may be chosen to suit different applications. Consequently, the attack rate is aggressive and the decay rate is slower than the attack rate.

When the variance decreases to the accumulation level divided by a pre-determined scale factor (**(*NoiseLevel).variance < (*NoiseLevel).accum[0]>>3?** in step E), the current accumulation is considered to bepart of a noise segment. This factor (>>3 = 8 in Step E) was chosen after comparing the ratio between different noise levels and corresponding variances of the accumulations. When it is decided that the accumulation is noise (step F), the noise level is calculated/updated with a decay ratio of 8 (i.e. >>3 in Step F). A decay ratio other than 8 may be chosen for different applications.

In the case where the noise level is greater than the accumulation, the noise level is reset to the current accumulation value (step G). This is to ensure that the noise level calculator is biased towards the lowest possible noise level.

Finally, some variables are re-initialized for the next accumulation window (step H).

It should be noted that, for the **ein** signal, the noise level is multiplied by a factor of 0.013 (which is 3.3/256, 256 being the Window size) before it is compared to an actual sample. For the **Rin_line** signal, the noise level is multiplied by a factor of 0.2 (50/256) which is on the high side for the noise threshold.

Alternatives and variations of the invention are possible. For example, real energy calculations can be used instead of taking the absolute value of the samples in step B, different window sizes may be used, and different attack and decay rates may be specified for updating the variance (step E). Furthermore, it is contemplated that the algorithm of the present invention may also be applied to detect voice (i.e. the absence of noise) and may be applied to the operation of a comfort noise generator for silence suppression. All such alternative embodiments and applications are believed to be within the sphere and scope of the invention as defined by the claims appended hereto.

I Claim:

1. A method of calculating noise level in a signal, comprising the steps of:

accumulating two sample windows of said signal;

calculating energy of said signal within each of said sample windows;

calculating the difference in said energy of said signal within each of said sample windows;

updating a variance parameter based on said difference;

in the event that said variance parameter is less than a predetermined multiple of the energy of said signal within a most recent one of said sample windows then indicating the presence of noise and setting a noise level parameter as a function of the energy of said signal within said most recent one of said sample windows, and in the event that said variance parameter is greater than or equal to than said predetermined multiple of the energy of said signal within said most recent one of said sample windows then indicating the absence of noise in said most recent sample window; and

in the event that said noise level parameter exceeds the energy of said signal within said most recent one of said sample windows then setting said noise level parameter to equal the energy of said signal within said most recent one of said sample windows.

2. The method of claim 1, further comprising the steps of discarding two successive ones of said sample windows at start up and for each subsequent first one of said two successive sample windows which exceeds a predetermined maximum energy.

3. The method of claim 1, wherein said step of updating said variance parameter further comprises the steps of:

comparing said variance parameter to said difference in said energy of said signal within each of said sample windows and setting said variance parameter to the weighted average of the difference and a previous value of the variance parameter; and

in the event that said variance parameter is greater than said difference then adjusting said variance parameter with a predetermined decay ratio, and in the event that said variance parameter is less than or equal to said difference then adjusting said variance parameter with a predetermined attack ratio..

4. The method of claim 1, wherein said step of setting the noise level parameter as a function of the energy of said signal within said most recent one of said sample windows further comprises setting said noise level parameter to the weighted average of the energy of said signal within said most recent one of said sample windows and a previous value of said noise level parameter.

Abstract

A method of calculating noise level in a signal, comprising the steps of accumulating two sample windows of the signal, calculating energy of the signal within each of the sample windows, calculating the difference in the energy of the signal within each of the sample windows, updating a variance parameter based on the difference, in the event that the variance parameter is less than a predetermined multiple of the energy of the signal within a most recent one of the sample windows then indicating the presence of noise and setting a noise level parameter as a function of the energy of the signal within the most recent one of the sample windows, and in the event that the variance parameter is greater than or equal to the predetermined multiple of the energy of the signal within the most recent one of the sample windows then indicating the absence of noise, and in the event the noise level parameter exceeds the energy of the signal within the most recent one of the sample windows then setting the noise level parameter to equal the energy of the signal within the most recent one of the sample windows.

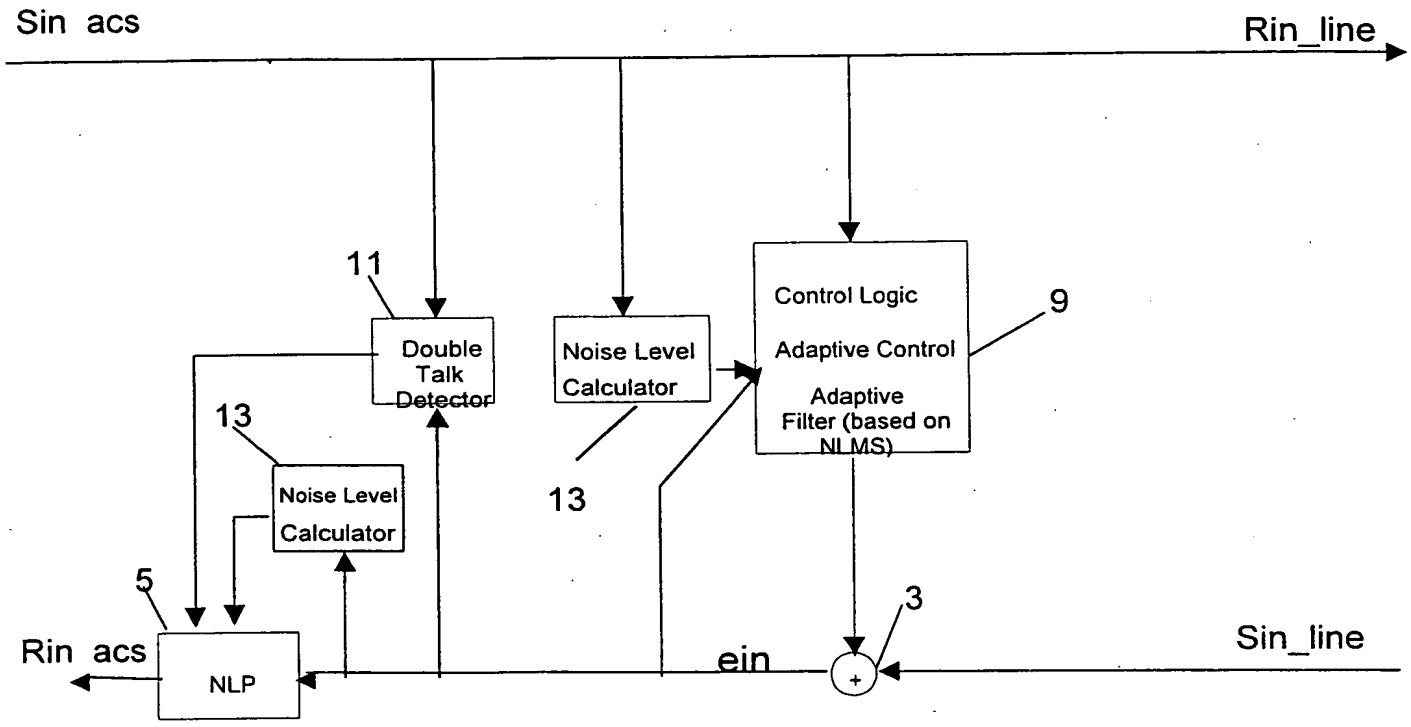
Sin acs
Rin_line
11
Double Talk Detector
Noise Level Calculator
Control Logic
Adaptive Control
Adaptive Filter (based on NLMS)
9
13
Noise Level Calculator
13
5
3
Rin acs
NLP
ein
Sin_line

Figure 1

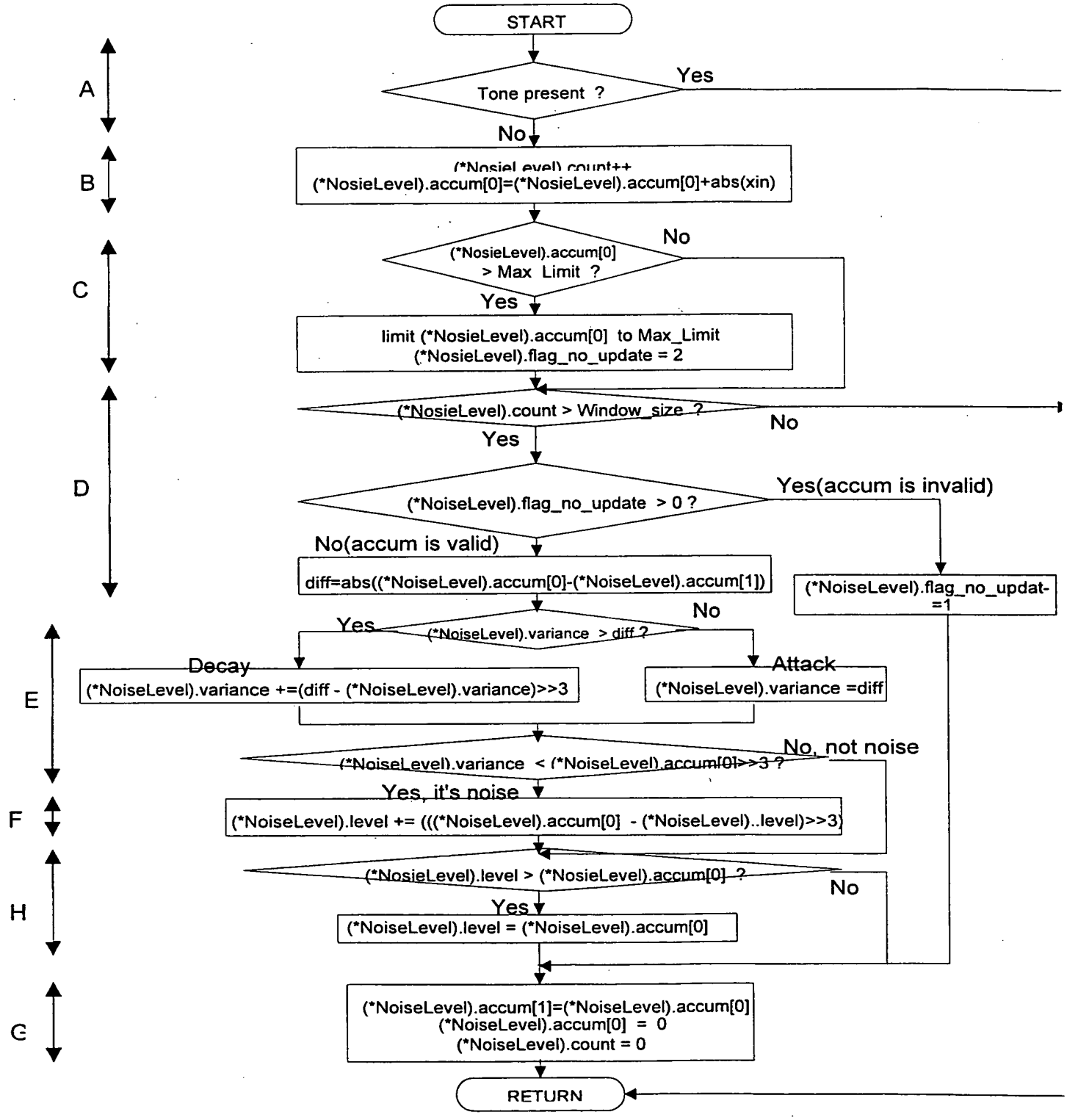
START
A
Tone present ?
Yes
No
B
(*NosieLevel).count++
(*NosieLevel).accum[0]=(*NosieLevel).accum[0]+abs(xin)
C
(*NosieLevel).accum[0]
> Max Limit ?
No
Yes
limit (*NosieLevel).accum[0] to Max_Limit
(*NosieLevel).flag_no_update = 2
(*NosieLevel).count > Window_size ?
No
Yes
D
(*NoiseLevel).flag_no_update > 0 ?
Yes(accum is invalid)
No(accum is valid)
diff=abs((*NoiseLevel).accum[0]-(*NoiseLevel).accum[1])
(*NoiseLevel).flag_no_updat-
=1
No
Yes
(*NoiseLevel).variance > diff ?
E
Decay
(*NoiseLevel).variance +=(diff - (*NoiseLevel).variance)>>3
Attack
(*NoiseLevel).variance =diff
No, not noise
(*NoiseLevel).variance < (*NoiseLevel).accum[0]>>3 ?
Yes, it's noise
F
(*NoiseLevel).level += (((*NoiseLevel).accum[0] - (*NoiseLevel)..level)>>3)
(*NosieLevel).level > (*NosieLevel).accum[0] ?
No
H
Yes
(*NoiseLevel).level = (*NoiseLevel).accum[0]
G
(*NoiseLevel).accum[1]=(*NoiseLevel).accum[0]
(*NoiseLevel).accum[0] = 0
(*NoiseLevel).count = 0
RETURN

Figure 2